

» **Case Report** «

# Intraoperative Migration of Open Stent Graft Detected by Transesophageal Echocardiography: Report of Two Cases

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We report two cases of graft migration during open stent grafting, detected by transesophageal echocardiography (TEE). The incidence was 3.7% in our series. The length of landing zone was reduced from 45 mm to 25 mm in case 1 and from 50 mm to 22 mm in case 2 before chest closure. Aneurysmal protrusion on the greater curvature with thin mural thrombus were findings common in both cases. Although additional intervention was not done based on the TEE findings of no endoleak and thrombus formation in the aneurysm, and postoperative course was uneventful, meticulous imaging check-up was needed.

**Keywords:** stent graft, complication, echocardiography

## Introduction

Graft migration is an infrequent but one of important complications of endovascular stent-graft implantation.<sup>1)</sup> It suddenly elevates the pressure in the aneurysm and potentially causes rupture, necessitating an emergency surgery despite that this treatment is indicated in patients with high risk for surgery. Although it potentially occurs in open stent grafting (OSG) as well, it may remain unrecognized until postoperative computed tomography (CT) or unfortunately aortic rupture occurs. Although fluoroscopic guidance is used at graft insertion in many institutes, it may not be able to accurately detect impending dislocation of the graft into the aneurysm since the aortic wall cannot be clearly visualized.

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We have used transesophageal echocardiography (TEE) in every case of OSG to detect and/or minimize undesirable complications which can take place in the blind zones for surgeons<sup>2,3)</sup> and recently found that the graft can migrate intraoperatively. This paper is aimed to report two cases in detail and to discuss the mechanism and best possible management of graft migration in OSG.

## Case Report

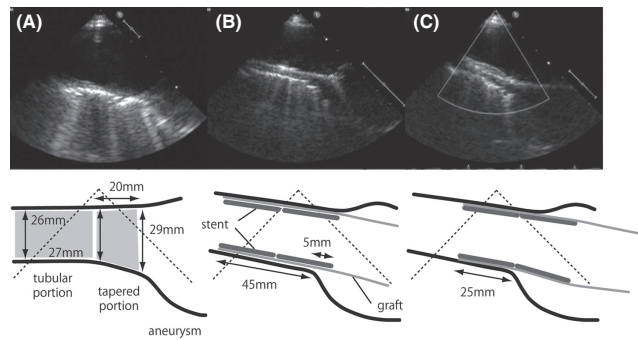
Case 1 was a 76-year-old male patient who underwent OSG for distal arch aneurysm with fusiform protrusion toward the outer curvature (55 mm) from 2 cm distal to the left subclavian artery with distal end at mid-portion of descending aorta. As previously reported,<sup>2,3)</sup> the stent graft was prepared with a 30 mm vascular prosthesis (Intervascular Inc, Clearwater, Florida, USA) in which a pair of Gianturco Z-stents (40 mm; Cook Inc., Bloomington, Indiana, USA) were suture-fixed. TEE showed, however, that the descending aorta distal to the aneurysm was slightly tapered (29 mm to 27 mm in diameter within 2 cm in length), followed by a tubular portion which was 26 mm in diameter (Fig. 1A). If the entire length of

stented portion was implanted in the latter, as it was the optimal level for secure fixation of the graft, the distal end of the graft could be too distal and the distance from the diaphragm could be inadequate: estimated as smaller than 9 cm. Taking the risk of paraplegia into consideration,<sup>2,3)</sup> we decided to place the distal stent in the tubular portion and the proximal stent at the tapering portion.

Cardiopulmonary bypass was established with an arterial line in the right axillary artery and the venous lines in the right atrium and superior vena cava. Under circulatory arrest at the rectal temperature of 25°C, selective cerebral perfusion was established via the bilateral axillary arteries and a cannula placed in the left common carotid artery. Upon aortotomy, the graft packed in a sheath catheter (10 mm in diameter) was introduced into the descending aorta and was deployed under TEE guidance but without a guide-wire for introducing the graft into the descending aorta. The proximal stent was placed in the tapered portion with 5 mm portion in the aneurysm (Fig. 1B). After proximal suture of the graft and closure of aortotomy, systemic perfusion was resumed. There was no detectable endoleak and the patient was weaned from cardiopulmonary bypass.

However, TEE revealed proximal migration of the graft within half an hour after weaning from bypass. The landing length decreased from 45 mm to 25 mm with proximal stent in the aneurysm (Fig. 1C). The distal end of graft was fixed with a single stent. Supposed mechanism of graft migration is shown in Fig. 2A. As cardiac output recovered, blood stream from the aortic arch pressed the graft in the aneurysm posteriorly (solid thick arrow). Since the blood adjacent to the graft was not solid and allowed fluctuation of the graft (double head arrow), it caused a traction force on the distal portion of graft (dotted arrow). At this time, we needed to decide whether or not to add any intervention. Our decision was watchful observation because the blood in the aneurysm was already coagulating by protamine and the mobility of graft was likely to decrease.

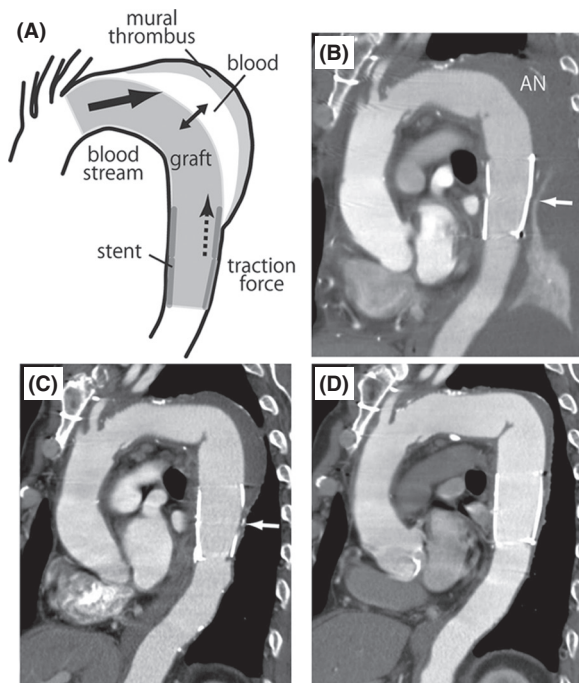
Instead, follow-up imaging was done more frequently than usual not to overlook further migration of the graft. Fortunately TEE confirmed no further migration after chest closure and on the first postoperative day before extubation. The CT examination on the 6th day showed that the intraoperative TEE diagnosis was correct and the graft stayed at the



**Fig. 1** Transesophageal echocardiograms showing graft migration in case 1. (A) Before implantation, there was a tapering portion at around the landing zone. (B) Immediately after implantation. Total length of landing was 45 mm and only 5 mm portion was in the aneurysm. (C) After weaning from cardiopulmonary bypass, the landing zone decreased to 25 mm.

same position with the graft fixed with a single stent (Fig. 2B: white arrow indicating the border of aneurysm). He had uneventful course and was discharged. Three months later, the aneurysm began to shrink without further graft migration (Fig. 2C). At 15th month, thrombus around the graft nearly disappeared and the graft at the proximal stent was well backed by the aortic wall. At this time, we concluded that the patient no longer had a risk of further migration (Fig. 2D).

Case 2 was a 72-year-old male patient who underwent OSG with arch first technique for distal arch aneurysm (62 mm) which was cystic with anterior and cephalad protrusion and involved the left subclavian artery (Fig. 3A). The manner of systemic perfusion and selective cerebral perfusion was similar to that in case 1. After the branches were anastomosed and adequately perfused, while the stumps were closed, a stent graft (UB-Dacron 36 mm with a pair of 40 mm Gianturco Z-stents, USA) was inserted via the aortotomy proximal to the innominate artery and was deployed in the descending aorta just distal to the aneurysm with a landing zone of 50 mm (full length of two stents) under TEE guidance. The proximal end of graft was sutured in the similar manner as in case 1, so that the entire arch and aneurysm was lined with the stent graft. As systemic perfusion was resumed, however, the length of landing zone was found to have been reduced to 35 mm by means of TEE (Fig. 3B). We terminated cardiopulmonary bypass while carefully overwatching the graft. Before chest closure, the graft further migrated and the landing length was as short as 22 mm (Fig. 3C).

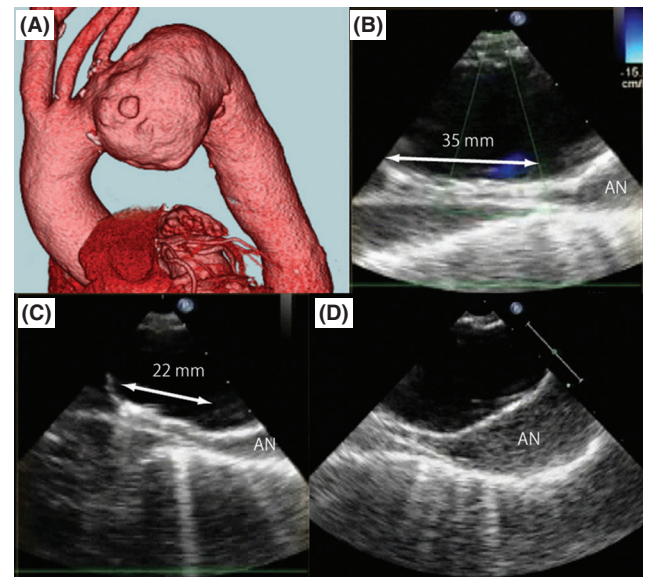


**Fig. 2** Schematic illustration showing possible mechanism of graft migration and postoperative computed tomograms. (A) Blood stream (thick arrow) compressed the graft in the aneurysm, which was flaccid in the blood (double arrow), then generated a traction force on the distal graft (dotted arrow). Computer tomogram at 6th day (B), 3 months (C), and 15 months (D) after surgery.

TEE showed there was no detectable blood flow in the aneurysm and clot formation was already noted (Fig. 3D). For the same reason as case 1, we decided a watchful observation. The patient was extubated on the next day after no further migration of the graft was confirmed by TEE. His postoperative course was uneventful and the CT assessment on the 10th and 28th postoperative day showed the accuracy of TEE diagnosis as well as no further migration of the graft. Although without apparent shrinkage of the aneurysm, there was no increase in aneurysmal size or further graft migration until the patient unfortunately died of cerebral hemorrhage at the 15th month of surgery.

## Discussion

To our best knowledge, there is no report on intraoperative migration of OSG detected by TEE. The incidence in this series was 3.7% (2 of 54 cases). It can occur before weaning from bypass or after the pump is terminated. Without TEE, migration was probably



**Fig. 3** Preoperative computed tomogram and transesophageal echocardiograms showing graft migration in case 2. (A) Preoperative computed tomogram. (B) After weaning from cardiopulmonary bypass. The length of landing was reduced from 50 mm to 35 mm. (C) Before chest closure. The landing length was further reduced to 22 mm. (D) Clot formation in the aneurysm (AN).

unrecognized and perioperative course would have appeared just uneventful until postoperative CT assessment which is usually done at 2 to 4 weeks after surgery, but with a risk of sudden aortic rupture due to stent migration into the aneurysm.

Whereas OSG is also called as “frozen elephant trunk”, the current cases appropriately illustrate that the graft is not perfectly “frozen”. In both cases of stent migration, the aneurysmal protrusion was on the greater curvature side of distal arch and had a large aneurysmal cavity with rather thin mural thrombus. Therefore, the unstented portion of graft was suspended in the free space in the aneurysm. The stent graft used in these cases had no skeleton except in the distal end unlike that used for endovascular stent graft implantation. As the direction of blood stream from the aortic arch is turned caudally at this portion, the counterpressure can work as traction force on the distal portion of the graft. If the middle portion is backed by a firm structure such as aortic wall as shown in Fig. 2D, mobility of the graft and traction force is likely to be minimal. However, only blood or clot is present behind the graft during surgery. After the distal end is deployed, the proximal graft is mildly pulled to avoid a kinking in the curved

portion. This maneuver also detaches the graft from the aortic wall. Although clot seems to support the graft better than blood, it is not clear how effectively the clot behind the graft prevents graft migration.

Anyhow, absence of blood flow and increased echogenicity assessed by TEE was the only information on the property of blood in the aneurysm. Despite that intraoperative aortography is available as well, information is limited. We previously found that echogenicity in the aneurysm remained low in cases with endoleak.<sup>3)</sup> If there had been endoleak of any type or inadequate clot formation in the current cases, we might have made a different decision. However, since it was uncertain how effectively clot could support the graft as mentioned above, we meticulously monitored any further migration using TEE and CT.

An option as the additional intervention to prevent aortic rupture at this moment would be endovascular stent grafting on the distal end of previous graft. However, we hesitated it because: (1) extended coverage of descending aorta could lead to paraplegia; and (2) manipulations in the aorta and graft might rather cause dislocation of graft into the aneurysm.

The specific feature in case 1 was the tapering portion of the aorta at the supposed landing zone. Radial expansion of the stent in the tapering portion may also cause sliding of the graft. More distal placement of graft would solve this problem, but it could increase the risk of paraplegia and this option was not chosen. Although such morphological feature is not rare, it is difficult to predict the result following graft deployment. Instead, we consider it practical to make a decision based on the result based on the real-time TEE findings.

In case 2, the graft had migrated proximally as early as at weaning from cardiopulmonary bypass despite that the graft size was adequate and there was no other obvious reason in the technical aspect. The only difference from other cases was that a thin UB-Dacron graft was used in this particular case. Unlike thick woven graft, its smooth surface could be more slippery. Since our graft has no flare at the distal end of graft, this may be a pitfall in OSG. Although these cases fortunately did not develop graft migration, careful follow-up is mandatory for years.

We have routinely used TEE in OSG not only for guiding graft insertion<sup>2,3)</sup> but for navigating the strategy or making decision in case of unpredictable events, because it is capable of visualizing the aorta and other pathologies such as atheroma or aortic dissection which is not hardly seen with fluoroscopy. We occasionally have such a dilemma as a longer landing zone for reducing the risk of migration leads to an increased risk of paraplegia as in case 1. TEE may be helpful for navigating a delicate strategy in such a conflicting situation. With improved outcomes of endovascular treatments which are carried out in hybrid OR, elimination of every preventable complication is expected. TEE may benefit for achieving this goal by providing additional information in the blind spot for fluoroscopy.

## Conclusion

Intraoperative graft migration can occur in OSG and the incidence was 3.7%. This event is to be kept in mind in cases with protrusion at the greater curvature side with thin mural thrombus, tapered configuration at the landing zone, or use of thin graft without flare. TEE appears to be useful for identifying the cases which necessitate meticulous check-up in the perioperative period.

## Disclosure Statement

None of the authors have any conflict of interest regarding the contents of this paper.

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